

University of California at Berkeley  
 Physics 129A  
 Professor Freedman  
 Fall 2004  
 September 19, 2004  
 Homework #3 (Due: Friday September 24)

1. Using the angular momentum ladder operators  $J_+$  and  $J_-$  construct a table of angular momentum coupling constants appropriate for combining angular momentum  $J_1 = 1$  with angular momentum  $J_2 = 1$ , to get the  $J = J_1 + J_2$  representations. You may note that there are ambiguities in the phase of the coefficients but you should be able to compare your results with the table on the PDG web site (<http://pdg.lbl.gov/>).

2. The Hamiltonian for an axial symmetric rotator is

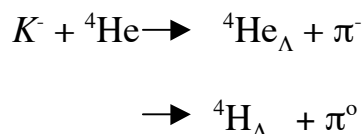
$$H = \frac{L_x^2 + L_y^2}{2I_1} + \frac{L_z^2}{2I_3}$$

(a) What are the eigenvalues of  $H$ ?

(b) Sketch the spectrum, assuming that  $I_1 > I_3$ .

(c) What is the spectrum in the limit that  $I_1$  is much larger than  $I_3$ ?

3. A  $\Lambda$ -hyper nucleus is one in which a neutron is replaced by a bound  $\Lambda$ -hyperon.  ${}^4\text{He}_\Lambda$  and  ${}^4\text{H}_\Lambda$  is a doublet of mirror hyper nuclei. Deduce the ratio of the reaction rates



4. (from Problem 4.32 Griffiths) The  $\Sigma^{*0}$  can decay into  $\Sigma^+ + \pi^-$ ,  $\Sigma^0 + \pi^0$ ,  $\Sigma^- + \pi^+$  or  $\Lambda + \pi^0$  which is the dominant decay mode. Ignoring the  $\Lambda + \pi^0$  mode how many decays to each of the other three modes would you expect if you observed a total of 100 disintegrations with  $\Sigma$ s in the final state? Look up the branching ratios in the PDG table. Why can't the  $\Lambda + \pi^0$  mode be estimated like the decays to  $\Sigma$ s. In order to test your prediction you must compare to a real experimental data and consider statistics. On the basis of statistics how many decays are required to get to summary values in PDG.